Index of Biotic Integrity: Overview, Derivation and Application

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Presentation Outline

- **Index of Biotic Integrity (IBI) definition and overview**

- **Linking the narrative biological criteria in the Texas Surface Water Quality Standards to the quantitative results of IBI's;**

- **Overview of the process used to derive IBI's in Texas;**

- **Overview of the application of the IBI to benthic macroinvertebrate Rapid Bioassessment (RBA) samples.**

Index of Biotic Integrity A Black Box?

Index of Biotic Integrity

→

- **IBI Total Score = 28**
- **Aquatic Life Use Category Indicated = Intermediate**
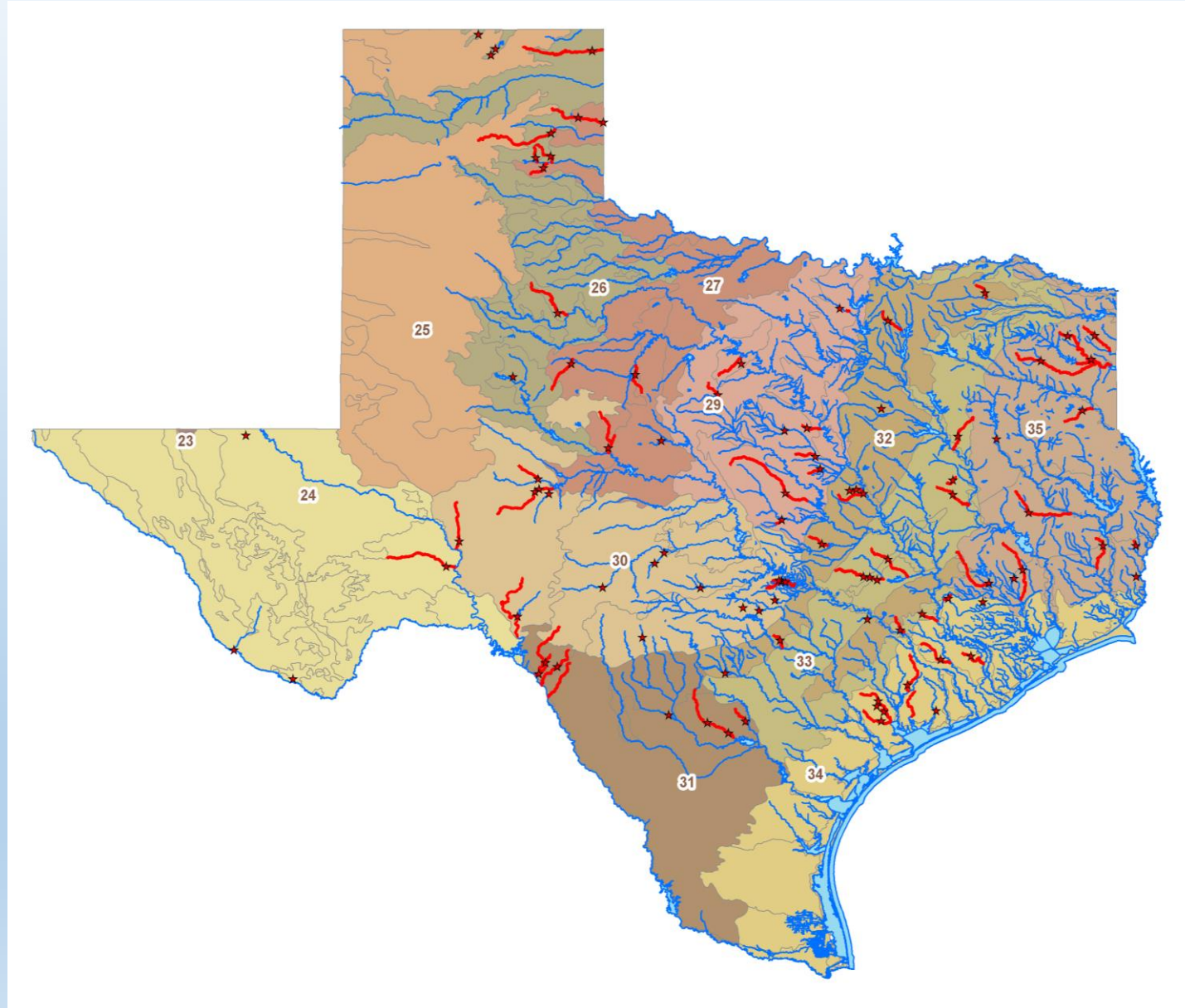- **Outcome: Does Not Attain Designated Use in TSWQS Appendix A**

- **Biological Integrity**: The species composition, diversity, and functional organization of a community of organisms in an environment relatively unaffected by pollutions.

- **Index of Biotic Integrity (IBI)**: Developed 1986 by James Karr, a set of metrics which integrate structural and functional aspects of aquatic assemblages in deriving measures of community health which are useable in managing aquatic resources. Quantitative expression of biological integrity.
    - Derived based on sampling conducted in Least Disturbed Reference Streams.
    - Allows development of a "composite" reference condition, represented by the metric set values.
    - The more similar study sites are to the "composite" reference condition represented by the IBI metric set, the higher the total IBI score/biotic integrity.

Biological Condition Gradient
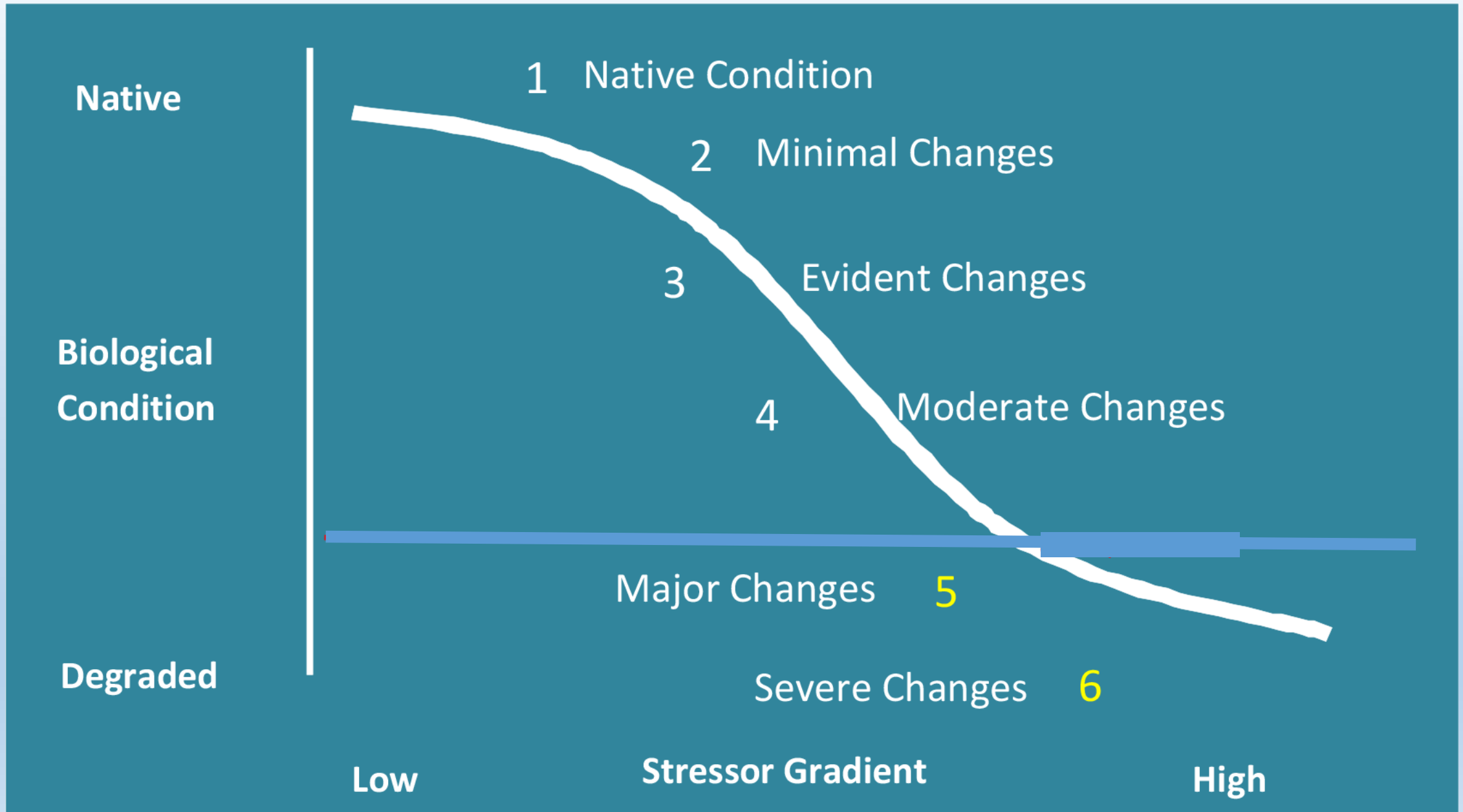
Bioassessment

- Integrated assessment, comparing habitat, water quality and biological measures with empirically defined reference conditions;

- Reference conditions established via systematic monitoring of actual sites that represent the natural range of variation in "least disturbed" water chemistry, habitat, and biological conditions.

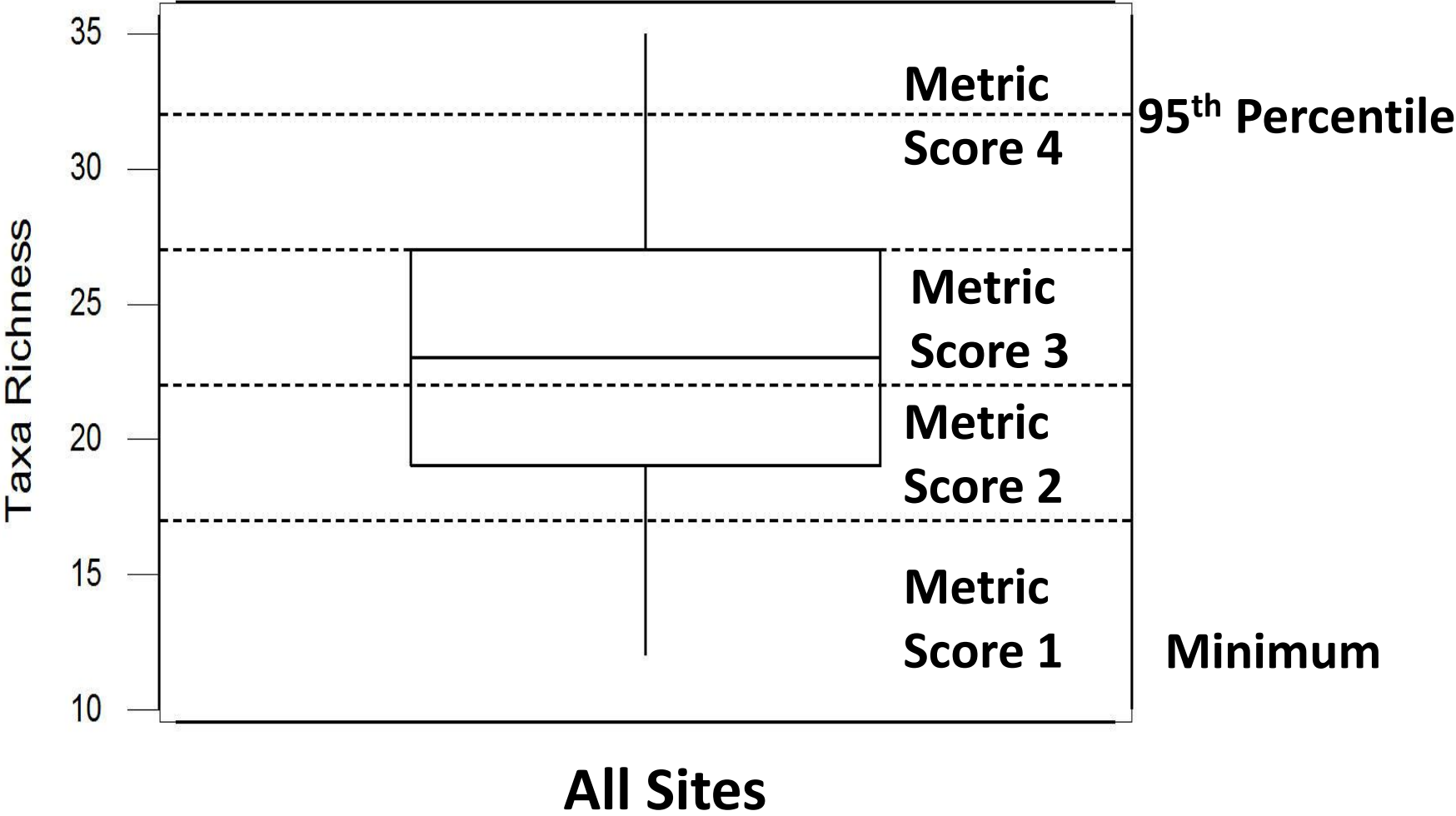| Aquatic Life Use Subcategory	Aquatic Life Attributes					
	Habitat Characteristics: Habitat Quality Index (HQI)	Species Assemblage	Sensitive Species	Diversity	Species Richness	Trophic Structure
Exceptional	Available Instream Cover	**Fish**: Number of native cyprinid spp.	**Fish**: # Intol spp. **Benthics**: # EPT taxa	**Fish & Benthics**: Taxa Richness	**Fish & Benthics**: Taxa Richness	Balanced
High	Number of riffles	**Fish**: Percent of individuals as non-native spp.	**Fish**: # Individuals as Tolerant **Benthics**: Ratio IT/T	**Fish**: # Native Cyprinid spp. **Benthics**: # Non-insect taxa	High	Balanced to slightly imbalanced
Intermediate	Bank Stability	**Fish & Benthics**: Taxa Richness	**Fish**: # Native Cyprinid spp. **Benthics**: Biotic Index (HBI)	**Benthics**: Percent dominant taxon	Moderate	Moderately imbalanced
Limited	Channel Sinuosity	**Fish**: # of Sunfish spp. **Benthics**: # of EPT taxa	**Fish & Benthics**: Taxa Richness	**Benthics**: Percent Chironomidae	Low	Severely imbalanced

IBI's provide a quantitative link to narrative Aquatic Life criteria in Table 3: Site Specific Uses

Regionalized IBI for RBA Benthic Macroinvertebrate Samples: 32 Candidate Metrics

- % Tanytarsini
- Count Chironomid Taxa
- Count Diptera Taxa
- % Diptera
- % Dominant Taxon
- % Diptera and Non-Insect Taxa
- Count Non-Insect Taxa
- % Corbicula
- % Oligochaeta
- % of Trichoptera as Hydropsychidae
- Ratio IT/T
- Count Intolerant Taxa
- % Tolerant Taxa
- Biotic Index
- Count Collector-gatherer Individuals

- Taxa Richness
- % Predator
- % Collector-Gatherers
- % Scraper-Collectors
- % Shredders
- % Filtering Collectors
- Count EPT Taxa
- % EPT
- Count Ephemeroptera Taxa
- Count Trichoptera Taxa
- % Ephemeroptera
- % Trichoptera
- % Chironomidae
- Count CG/FC individuals
- % CG/FC
- Count Predator Individuals
- % Elmidae

Example: IBI Metric
Benthic Macroinvertebrate Richness

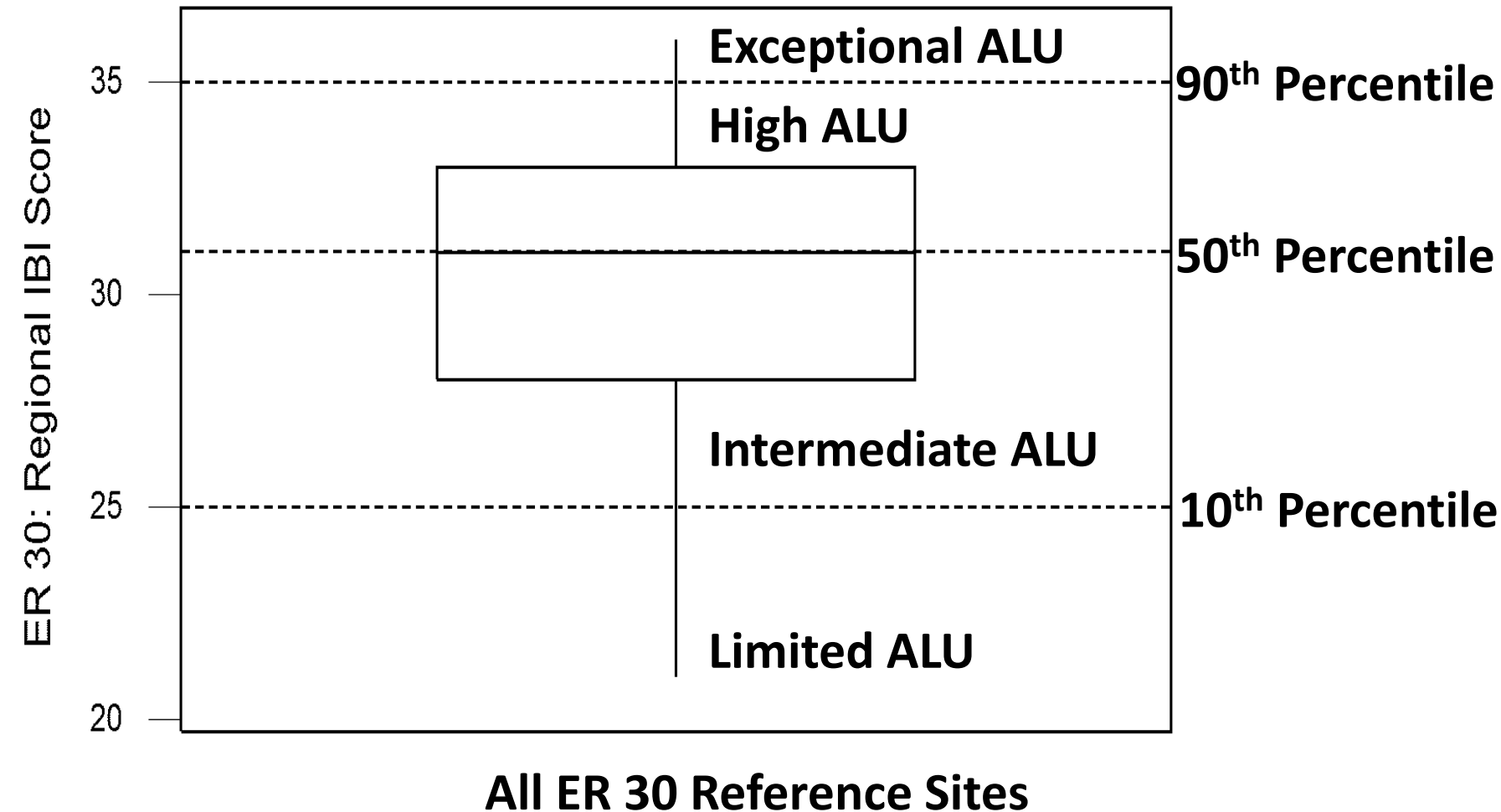(Number of Taxa vs. Human Disturbance Gradient)
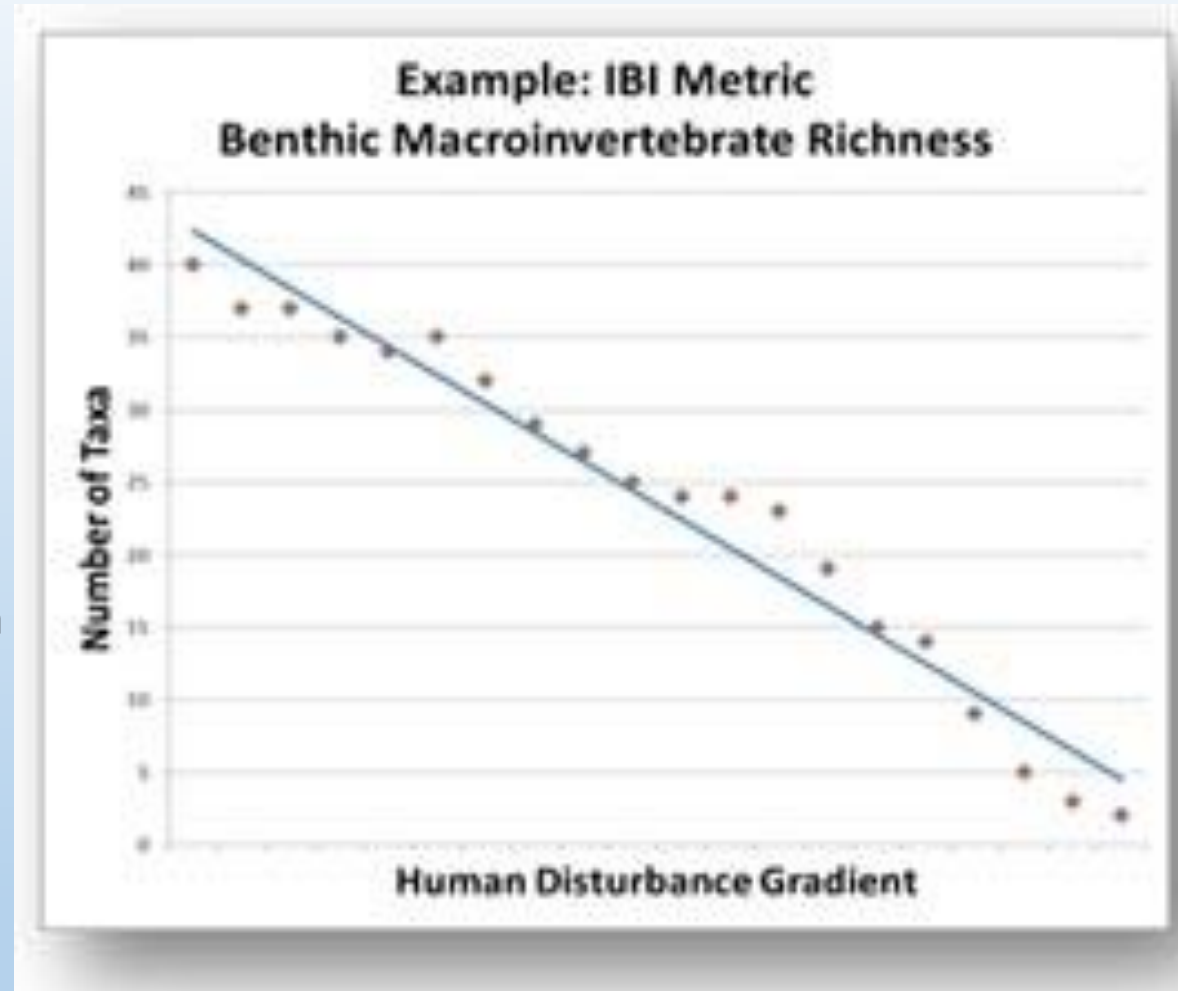
Derivation of metric scores using the 95th Percentile as a standard

1. Rank metric values from all sample sites in descending order.
2. Compute the 95th percentile.
3. Determine the minimum metric value from all sites.
4. Quadrasect the interval between the minimum and the 95th percentile.
5. Assign scores to each interval.

Metric	Scoring Criteria			
Richness and Composition Measures	4	3	2	1
1. Total Number of Taxa	>28	18-28	8-17	<8
2. Number of EPT Taxa	>13	9-13	4-8	<4
3. % Diptera and Non-Insects	1.92-18.92	18.93-35.93	35.93-52.93	<1.92 or >52.93
4. % Dominant Taxon	<21.46	21.46-32.58	32.59-43.71	>43.71
Functional Composition				
5. % Dominant Functional Group	<36.68	36.68-45.68	45.69-54.69	>54.69
6. % Shredder	0.31-3.84	3.85-7.36	7.37-10.87	<0.31 or >10.87
7. % Scraper	0.21-7.92	7.92-15.63	15.64-23.34	<0.21 or >23.34
Tolerance Measures				
8. Hilsenhoff Biotic Index (HBI)	<4.26	4.26-5.18	5.19-6.12	>6.12
9. Number of Intolerant Taxa	>28	22-28	15-21	<15
10. % Tolerant Organisms	<2.69	2.69-5.38	5.39-8.07	>8.07

Derivation of Aquatic Life Use Categories using the 90th Percentile as a standard.

ER 30: Regional IBI Score

- Exceptional ALU
- High ALU
- Intermediate ALU
- Limited ALU

90th Percentile
50th Percentile
10th Percentile

All ER 30 Reference Sites

1. Rank the total IBI scores from all reference sites in descending order
2. Compute the 90th, 50th, and 10th percentiles for the ranked total IBI Scores.
3. Exceptional ALU defined as any IBI score equaling or exceeding the 90th percentile.
4. High ALU defined as any IBI score equal to the 50th and less than the 90th percentile.
5. Intermediate ALU defined as any IBI score less than the 50th percentile and greater than or equal to the 10th percentile.
6. Limited ALU <10th percentile

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Aquatic Life Use Category	Benthic Macroinvertebrate IBI Score Range
Exceptional	≥35
High	30-34
Intermediate	23-29
Limited	<23

Aquatic Life Use Subcategory	Aquatic Life Attributes					
	Habitat Characteristics	Species Assemblage	Sensitive Species	Diversity	Species Richness	Trophic Structure
Exceptional	Outstanding natural variability	Exceptional or unusual	Abundant	Exceptionally high	Exceptionally high	Balanced
High	Highly diverse	Usual association of regionally expected species	Present	High	High	Balanced to slightly imbalanced
Intermediate	Moderately diverse	Some expected species	Very low in abundance	Moderate	Moderate	Moderately imbalanced
Limited	Uniform	Most regionally expected spp. absent	Absent	Low	Low	Severely imbalanced

IBI's provide a quantitative link to narrative Aquatic Life criteria in Table 3: Site Specific Uses and Criteria, Aquatic Life in 307.7(b)(3)(A)(i) Texas Surface Water Quality Standards.

IBI Used to Determine the Position of Streams Along the Biological Condition Gradient
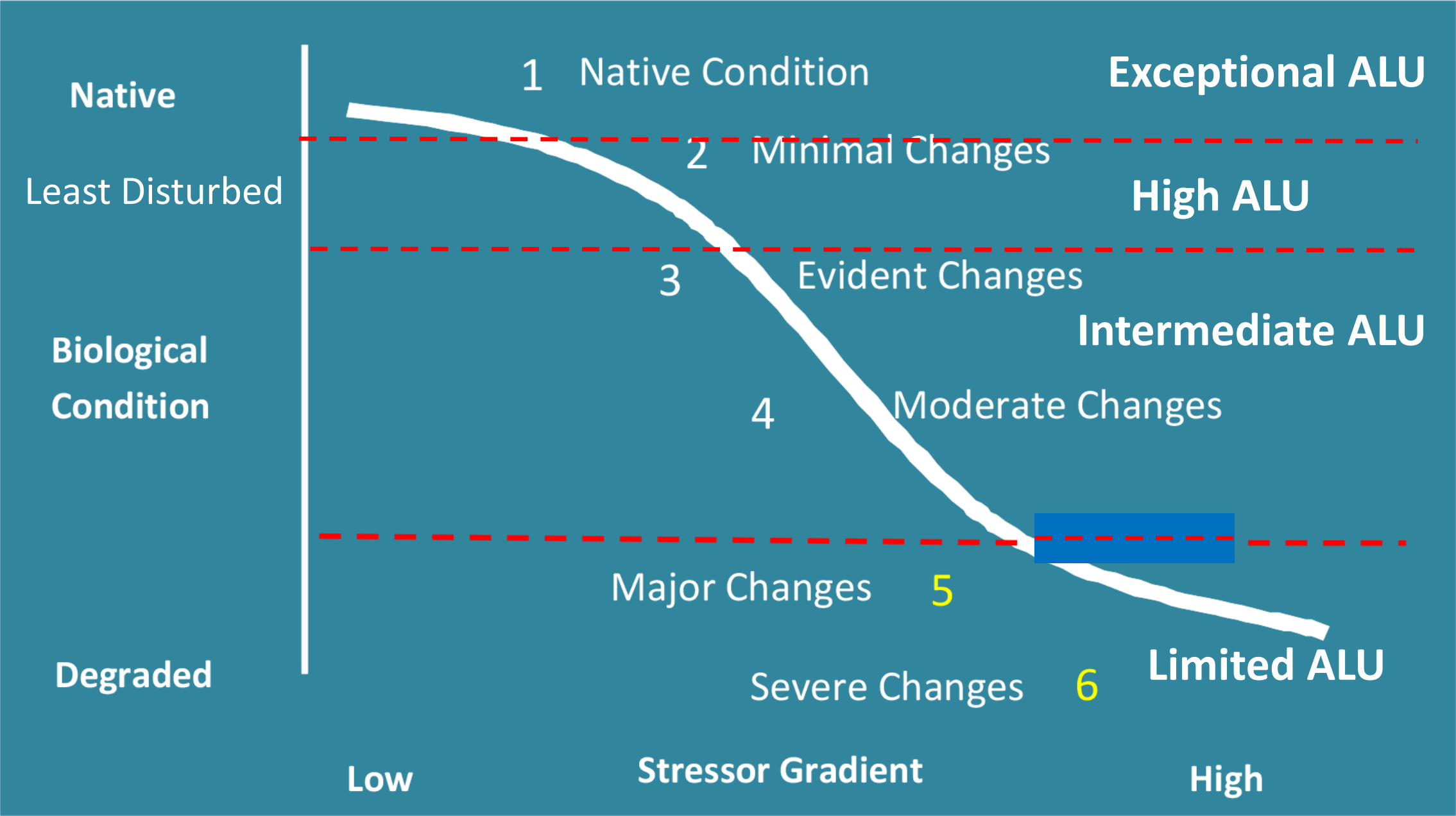
Benthic macroinvertebrate taxa collected from Cypress Creek near Cypress Mill, Blanco Co., TX; 09/10/1994; 5-minute Kicknet in riffle	Tolerance Value	Functional Group	
Taxon			**n**
Centroptilum sp.	2	scr/cg	30
Stenonema sp.	4	scr/cg	10
Caenis sp.	7	scr/cg	3
Leptohyphes sp.	2	cg	3
Tricorythodes sp.	5	cg	4
Isonychia sp.	3	fc	1
Cheumatopsyche sp.	6	FC	22
Hydropsyche sp.	5	fc	1
Chimarra sp.	2	fc	24
Dubiraphia sp.	5	scr/cg	5
Elsianus sp.	4	scr/cg	1
Hexacylloepus sp.	2	scr/cg	15
Microcylloepus sp. (19 adult & 1 larva)	2	SCR/CG	20
Lutrochus sp. (adult)		shr	1
Macromia sp.	3	p	1
Argia sp.	6	p	20
Enallagma sp.	6	p	2
Hetaerina sp.	6	p	20
Dicrotendipes sp.	7	cg/fc	1
N			184

Table of Benthic Macroinvertebrate tolerance values and functional feeding groups

Storet Code	Genus/Species	Tolerance Value	Functional Group	Order	Family
91645	*Acentrella sp.*	4	SCR/CG	Ephemeroptera	Baetidae
91632	*Acerpenna sp.*	4	SCR/CG	Ephemeroptera	Baetidae
91646	*Baetis sp.*	4	SCR/CG	Ephemeroptera	Baetidae
91642	*Baetodes sp.*	4	SCR	Ephemeroptera	Baetidae
91650	*Callibaetis sp.*	4	CG	Ephemeroptera	Baetidae
91644	*Centroptilum sp.*	2	SCR/CG	Ephemeroptera	Baetidae
91648	*Cloeon sp.*	4	SCR/CG	Ephemeroptera	Baetidae
91649	*Dactylobaetis sp.*	4	SCR/CG	Ephemeroptera	Baetidae
91651	*Fallceon sp.*	4	SCR/CG	Ephemeroptera	Baetidae
91579	*Labiobaetis sp.*	4	SCR/CG	Ephemeroptera	Baetidae
91656	*Paracloeodes sp.*	9	SCR/CG	Ephemeroptera	Baetidae
91654	*Pseudocloeon sp.*	4	SCR/CG	Ephemeroptera	Baetidae
91598	*Brachycercus sp.*	3	CG	Ephemeroptera	Caenidae
91600	*Caenis sp.*	7	SCR/CG	Ephemeroptera	Caenidae
91570	*Hexagenia sp.*	6	CG	Ephemeroptera	Ephemeridae
91590	*Isonychia sp.*	3	FC	Ephemeroptera	Oligoneuriidae
91607	Heptageniidae	4	SCR/CG	Ephemeroptera	Heptageniidae

Benthic macroinvertebrate taxa collected from San Gabriel River at SH 29; Station ID 12102; 07/21/2008'; 5-MIN. KICKNET	Value	Score
Taxa Richness	23	4
EPT	8	3
Biotic Index	4.72	2
% Chironomidae	2.283105	4
% Dominant Taxon	18.26484	4
% Dominant Functional Group	26.56012	4
% Predators	24.04871	3
Ratio Intolerant to Tolerant Taxa*	1.12	1
% of Total Trichoptera as Hydropsychidae	39.66	3
Number of Non-insect taxa	4	3
% Collector-Gatherers	26.56	3
% of n as Elmidae	33.33	1
Total Score		35

Point Score Ranges

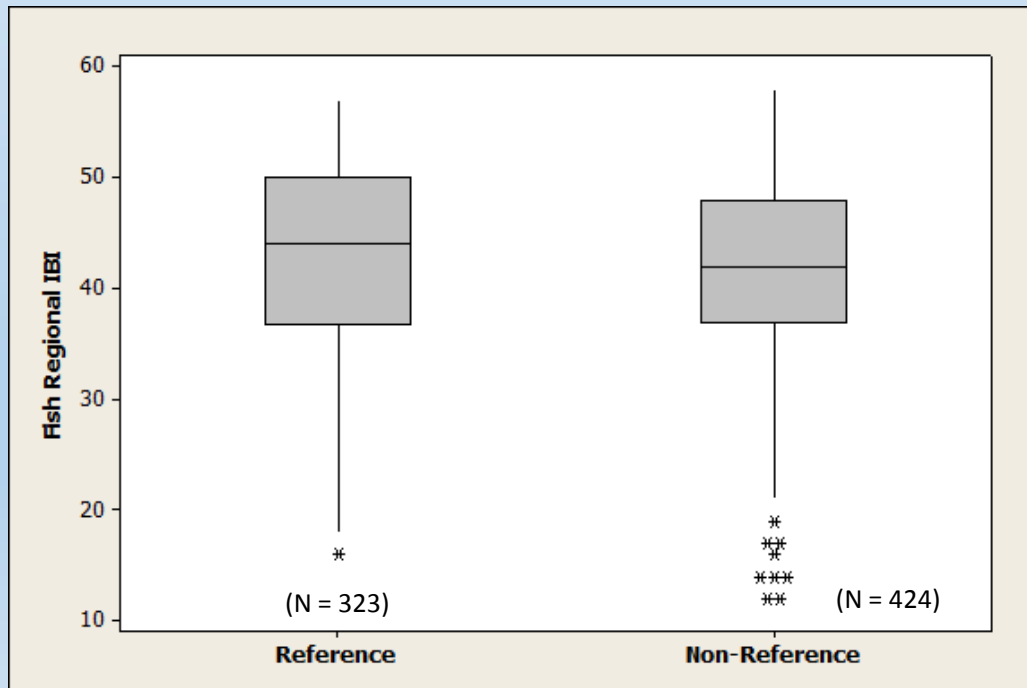|	
Exceptional	>36
High	29 - 36
Intermediate	22 - 28
Limited	<22
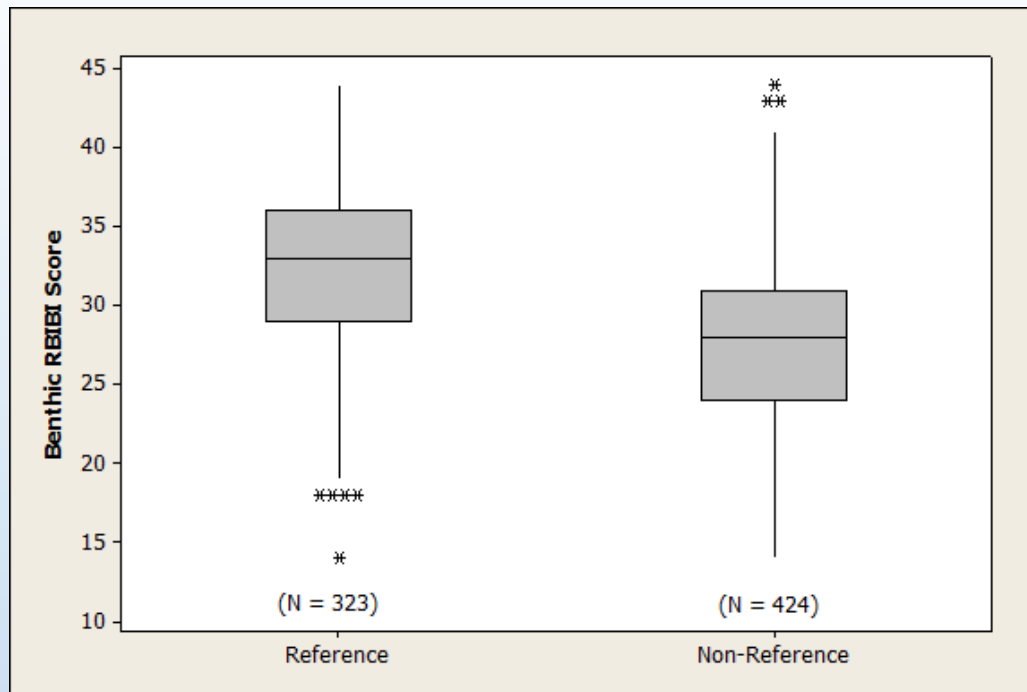
Reference stream sampling:
- to develop assessment tools such as the Index of Biotic Integrity (IBI);
- Least Disturbed Streams across the state to develop points of comparison for streams with more disturbance in the watershed.

The top boxplot shows a comparison of the distribution of Benthic IBI Scores for individual sample events at Least Disturbed Reference Streams to the distribution of Benthic IBI Scores at Non-Reference Streams.

The lower boxplot shows the same comparison for the Fish IBI.

Texas is very diverse, geographically and climatologically;
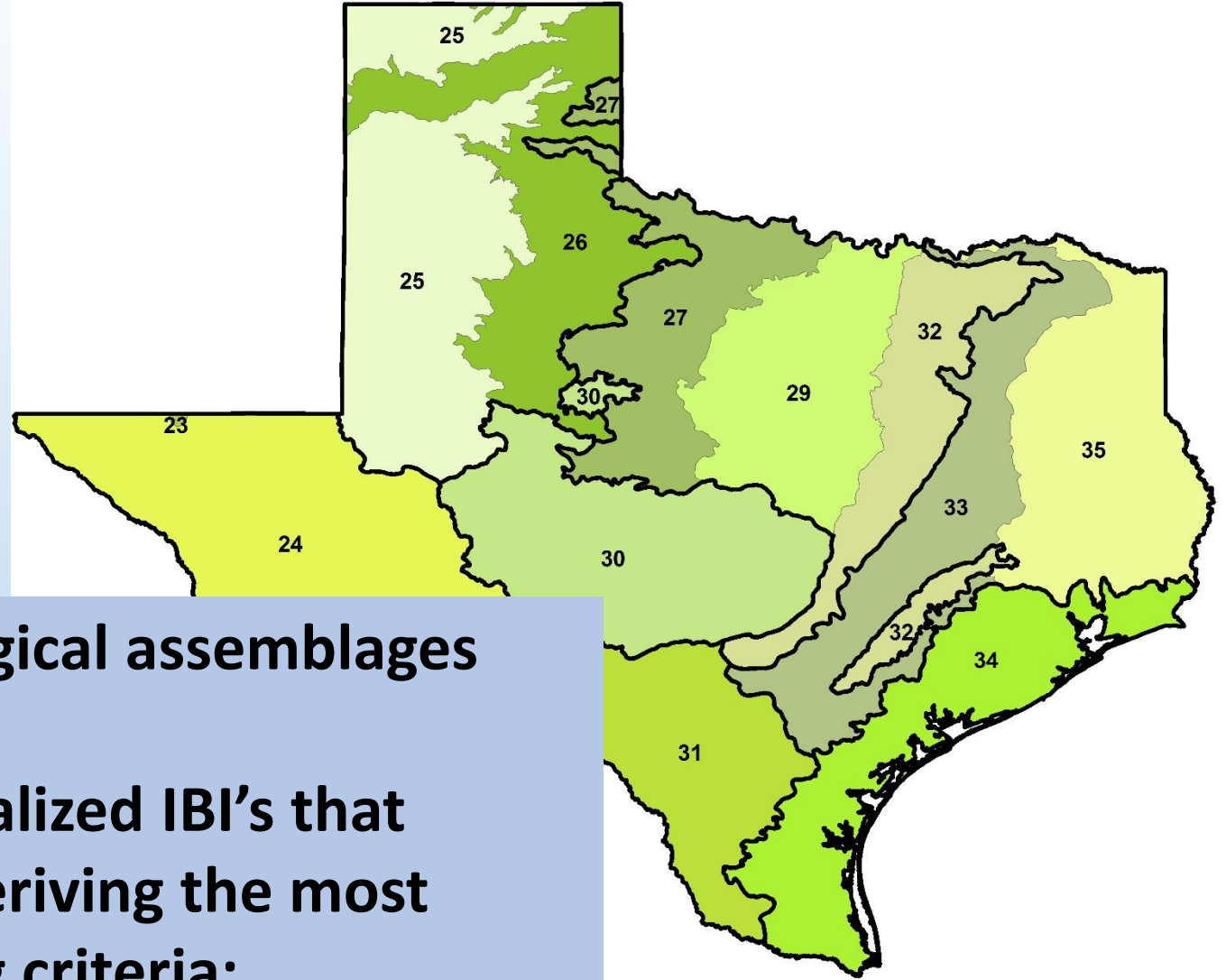
Characteristics of in-stream biological assemblages vary across the state accordingly:
- **Necessitates developing regionalized IBI's that incorporate this variability in deriving the most appropriate metrics and scoring criteria;**
  - **TPWD Regionalized Fish IBI (2002);**
  - **TCEQ Regionalized Benthic Macroinvertebrate IBI (Draft 2015);**

Summary

- The condition of in-stream biota is expected to change as the level of stress in the watershed changes.

- The Index of Biotic Integrity is a tool which allows estimating the position of a stream along the biological condition gradient.

- The IBI's used in Texas are developed based on the collection of biological data from Least Disturbed Reference Streams in Texas.

- Diversity of ecological settings for streams in different ecoregions in Texas necessitates development of regionalized IBI's.

- IBI's provide a quantitative link to narrative biological criteria in the Texas Surface Water Quality Standards.

- IBI's facilitate determining the aquatic life use category attained in a water body.

Questions?

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